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1213795

DRAWINGS ATTACHED

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## (54) IMPROVEMENTS IN VEHICLE SUSPENSION SYSTEMS


(71) I, NORBERT HAMY, a Canadian Citizen, of Lakeland House, Lake Road, Deepcut, Surrey, England, Great Britain formerly of 821, Roe Street, Regina, Saskatchewen, Canada, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—


This invention relates to wheeled vehicles and is particularly concerned with wheeled vehicle suspension systems.

According to the present invention, there is provided a wheeled vehicle including a body, a support member arranged transversely of the vehicle generally in the vertical plane containing the axis of rotation of a pair of wheels of the vehicle, the chassis being mounted on the support member at a point or at points thereon above the centre of gravity of the body for lateral swaying movement relative to the support member about a sway axis above the centre of gravity of the body, wheel mountings one for each wheel of the said pair, each mounting having a lower suspension joint and an upper suspension joint, wheel mounting location members each connecting one of the lower suspension joints to the said support member and providing transverse location of the wheel mountings, control link means connecting the upper suspension joints with the body whereby movement of the body in one lateral direction relative to the support member causes movement of the upper suspension joints relative to the support member in the opposite lateral direction, and means providing longitudinal location of the wheels relative to the body.

It is intended that the expression "body" used herein and in the appended claims be construed to mean the "chassis" together with the passenger compartment whether these are formed separated or as an integral unit.

Embodiments of the invention will now be described, by way of example, with reference to the drawings in which:—

Fig. 1 is a diagrammatic representation of the front suspension of a wheeled vehicle in accordance with the present invention as viewed from the front,

Fig. 2 shows the suspension of Fig. 1 as deflected during a right-hand turn,

Fig. 3 is a plan view of Fig. 1,

Fig. 4 is a diagrammatic representation as in Fig. 1, but shows a modification,

Figs. 5 to 7 inclusive show further modifications of the principle of Fig. 1,

Fig. 8 is a partial plan view on the line A—A in fig. 7,

Fig. 9 shows the suspension of Fig. 7 as deflected during a left-hand turn,

Fig. 10 is a part sectional view on the line B—B in fig. 7,

Fig. 11 is a diagrammatic representation as in Fig. 4, but shows an alternative springing arrangement,

Fig. 12, is a modification of the suspension shown in fig. 11,

Fig. 13 shows a still further modification of the principle of Fig. 1,

Fig. 14 is similar to Fig. 13, but shows an alternative spring arrangement,

Fig. 15 is similar to fig. 14, but shows a slightly modified geometry,

Fig. 16 is a sectional front elevation of a road wheel mounting, the section being taken on line C—C in fig. 17,

Fig. 17 is a sectional plan on the line D—D in fig. 16,

Fig. 18 is a sectional side elevation of part of one road wheel mounting showing the springing arrangement in a neutral position,

Fig. 19, is sectional plan view on the line E—E in Fig. 18,

Fig. 20 shows the springing arrangement of Fig. 18 as deflected under "bump" conditions,

Fig. 21 shows the springing arrangement of Fig. 18 as deflected under rebound conditions, and

Fig. 22 is similar to fig. 5, but shows an alternative springing arrangement.

In fig. 1 of the drawings, the vehicle body

30 is pivotally supported on a support member 31 at a point 32 thereon above the centre of gravity 33 of the body 30 on a longitudinal centre line of the vehicle. The support member 31 is arranged transversely of the vehicle generally in the vertical plane containing the axis of rotation of the opposed pair of front wheels 34. The hubs (not shown) of the wheels 34 are supported on wheel mountings 35 each of which has a lower suspension joint 36 and an upper suspension joint 37. The joints 36 and 37 are located on the steering axis of their respective wheels and are ball joints. The steering mechanism is omitted from fig. 1 for the sake of clarity. Lateral extensions 38 of the support member 31 form wheel mounting locating members and are pivotally connected at their extremities to the lower suspension joints 36 and provide transverse location of the wheel mountings 35. The upper joints 37 are connected to the body 30 by way of control link means in the form of control arms 39 which extend from the joints 37 to a pivotal connection 40 on the body 30. Each control arm 39 is arranged parallel to a line passing through a lower joint 36 and the point 32.

Longitudinal location of the wheels 34 relative to the body 30 may be of the link type or track type as shown in fig. 3 wherein the link type includes radius rods indicated at 41 and wherein track type includes opposed vertical slide faces indicated at 42. Fig. 3 also includes a diagrammatic representation of the steering mechanism which is indicated at 43 and is mounted on the support member 31. The wheels 34 are resiliently mounted on the mountings 35 for vertical upward and downward movement relative thereto. The construction and operation of such a resilient mounting is described later herein, as are alternative forms of resilient wheel mounting or springing. The important factor in respect of the wheel springing is that the roll centre of the wheels is below the centre of gravity of the body, preferably at road level.

Thus, in fig. 1, the vehicle front suspension is such that the support member 31 has a roll centre or sway axis which is located at road level at a point indicated at 44 due to the wheels 34 being resiliently mounted for vertical movement, and the body 30 has a sway axis at the point 32 which is above the centre of gravity 33 of the chassis 30.

The action of the front suspension during cornering is as follows:

Under centrifugal force, the centre of gravity 33 of the body 30 swings outwards about the sway axis through the point 32. The point 40 is thus forced inwards causing the control arms 39 to force the tops of the wheels 34 inwards through the joints 37. The effect as so far described, is that of an inward banking body and wheels. Due to the effect of weight transfer on the support member 31, the outer end of which dips and the inner end of which rises as permitted by the resilient mounting of the wheels 34, the resultant attitude is one of a level body and vertical wheels. It will be understood that the action of the suspension is influenced by a number of factors such as the rate of the vehicle when cornering, the distances between the various pivot points and the stiffness of the resilient mountings of the wheels, and that the geometry may be arranged so that a desired banking of the body and the wheels is achieved during cornering. The action of the suspension of fig. 1 is illustrated in fig. 2 wherein the vehicle is turning to its right, the body 30 having moved bodily to its left while remaining substantially vertical, the wheels remaining substantially vertical, and the support member 31 tilting outwards.

In fig. 4, parts corresponding with those described with reference to figs. 1 to 3 are given the reference numerals used in figs. 1 to 3 with the addition of prefix numeral 1. The body 130, the support member 131, the wheels 134 and the wheel mountings 135 are as described for fig. 1. The resilient wheel mountings indicated at 145 are described later herein and permit the wheels 134 to move vertically relative to the mountings 135. In addition to the control arms 139, the control link means includes a control link 146 which is pivotally mounted intermediate its ends on the support member 131 at 147. The control arms 139 are horizontal and have their inner ends pivotally connected to the link 146 at 148 and the link 146 has a lower vertically disposed slot 149 which engages a pin 150 secured to the body 130 so that lower end of the link 146 is in transverse locating engagement with the body 130.

The action of the suspension of fig. 4 is similar to that of fig. 1 except that the inner ends of the control arms are located below the sway axis through point 132 and the link 146 acts as a reversing link so that outward movement of the centre of gravity 133 and thus the pin 150 results in inward movement of the control arms 139 during cornering.

In fig. 5, parts corresponding with those described with reference to figs. 1 to 3 are given the reference numbers used in figs. 1 to 3 with the addition of the prefix number 2. The body 230 is mounted on the support member 231 by way of two control links 245 which are pivotally mounted intermediate their ends on the support member 231 on laterally spaced link axes through the points 246 above the centre of gravity 233 of the body 230. The upper ends of the links 245 are pivotally connected to the body 230 on longitudinal axes through points 247 which

are displaced inwards from the points 246, and the lower ends of the links 245 are provided with sliding sockets 248 which engage with the upper ball joints 237. Thus, the body 230 is mounted on the support member 231 for lateral swaying movement relative thereto about a sway axis 249 located approximately at the intersection of lines through the points 246 and 247. The wheels are resiliently mounted at 250 for vertical movement relative to the mountings 235 in a manner to be described later herein.

The action of the suspension of fig. 5 is similar to that described for fig. 4, the links 245 forming the control link means and acting as reversing links during cornering.

In fig. 6, parts corresponding with those described with reference to figs. 1 to 3 are given the reference numerals used in figs. 1 to 3 with the addition of the prefix numeral 3. This embodiment is similar to that of fig. 5, the body 330 being mounted on the support member 331 by means of two control links 345 which are pivotally connected to the body 330 about axes through points 346 and are pivotally connected to the support member 331 about axes through points 347. The instantaneous chassis sway axis 348 is located at the intersection of lines passing through the points 346 and 347. The wheels 334 have resilient mountings 348A as in fig. 5. There are two lower suspension joints 336 on each wheel mounting 335 (as to be described with reference to figs. 7 to 10), and the wheel mounting location members are in the form of two parallel tie bars 349 which are mounted on the support member 331 through pivotal links 350 as described with reference to Fig. 8.

The action of the suspension of fig. 6 is similar to that described for fig. 5.

In figs. 7 to 10, parts corresponding with those described with reference to figs. 1 to 3 are given the reference numerals used in figs. 1 to 3 with the addition of the prefix numeral 4. As in figs. 5 and 6, the body 430 is mounted on the support member by means of two control links 445 pivoted on axes through points 446 and 447 on the body 430 and the support member 431 respectively, the instantaneous sway axis 448 being located at the intersection of lines through these points. The wheels 434 are resiliently mounted for vertical movement relative to their mountings 435 by virtue of the hubs 449 of the wheels 434 being carried on forked carriers 450 which are telescopically received one in each mounting 435. (Means providing springing or resilience are not shown, but may be through pneumatic or other spring medium.) The mountings 435 each have two lower suspension joints 436 and wheel mounting location members are in the form of parallel tie bars 451 mounted on the support member 431 by way of parallel pivoted links 452 which are pivotted on the support member 431 about vertical axes through points 453. The action of the suspension of figs. 7 to 10 is similar to that described for figs. 5 and 6, and fig. 9 illustrates the deflection of the suspension during a left-hand turn, the centre of gravity 433 being shown in relation to its position 433 A before deflection.

In fig. 11, the parts corresponding with those described with reference to fig. 4 are given the reference numerals used in fig. 4 with the prefix number 5 in place of the prefix numeral 1. The construction and action of the suspension of fig. 11 is similar to that described with reference to fig. 4 with the exception that the wheel mounting location members are in the form of horizontal location arms 551 which are pivotally connected to the support member 531 for angular movement relative thereto in the vertical plane about axes passing through points 552. The wheels 534 together with their mountings 535 are resiliently mounted for independent upward and downward movement about the roll centre 544 by means of conventional spring shock absorbers 553 which are pivotally connected to the support member 531 at points 554 and to the mountings 535 through points 555 on the location arms 551, the location arms 551 and the control arms 539 forming horizontal parallelograms.

In fig. 12, parts corresponding with those described with reference to fig. 11 are given the reference numerals used in fig. 11 with the prefix numeral 6 in place of the prefix numeral 5. The construction and action of the suspension of fig. 12 is similar to that of fig. 11, the only difference being the provision of two control links 646 in place of one.

In fig. 13, parts corresponding with those described with reference to figs. 1 to 3 are given the reference numerals used in figs. 1 to 3 with the addition of the prefix numeral 7. The body 730 is mounted on the support member 731 by way of two control links 745 pivotally mounted intermediate their ends on the support member 731 on laterally spaced link axes through the points 746 above the centre of gravity 733 of the body 730. The lower ends of the links 745 are pivotally connected to the body 730 on respective longitudinal axes through points 747 which are displaced outwards from the points 746. The upper ends of the links 745 are connected to the upper suspension joints 737 by way of control arms 748 which are pivotted to the links 745 about longitudinal axes through the points 749. Thus the body 730 is mounted on the support member 731 for lateral swaying movement relative thereto about an instantaneous sway axis 750 located at the intersection of lines through the points 746 and 747. The wheels 734 are resiliently mounted at 751 for vertical movement relative to

the mountings 735 in a manner to be described later herein.

The action of the suspension of fig. 13 is similar to that described for figs. 4 and 5, the links 745 together with the control arms 748 forming the control link means, and the links 745 acting as reversing links during cornering.

In fig. 14, parts corresponding with those described with reference to fig. 13 are given the reference numerals used in fig. 13 with the prefix numeral 8 in place of the prefix numeral 7. The construction and action of the suspension of fig. 14 is similar to that described with reference to fig. 4 with the exception that the wheel mounting location members are in the form of horizontal location arms 852 which are pivotally connected to the support member 831 for angular movement relative thereto in the vertical plane through the wheel centres about axes passing through points 853. The wheels 834 together with their mountings 835 are resiliently mounted about the roll centre 844 by means of conventional spring shock absorbers 854 which are pivotally connected to the support member 831 at points 855 and to the mountings 835 through points 856 on the location arms 852, the location arms 852 and the control arms 848 forming horizontal parallelograms.

In fig. 15, parts corresponding with those described with reference to figs. 1 to 3 are given the reference numerals used in figs. 1 to 3 with the addition of the prefix numeral 9. The body 930 is mounted on the support member 931 by means of two control links 945 which are pivotally connected to the support member 931 about laterally spaced link axes through points 946. The upper ends of the links 945 are pivotally connected to the body 930 about respective longitudinal axes through points 947 which are displaced inwards with respect to points 946 above the centre of gravity 933 of the body 930. The lower ends of the control links 945 are connected to the upper suspension joints 937 by way of control arms 948 pivotally connected to the links at points 949. Thus the chassis 930 is mounted on the support member 931 for lateral swaying movement relative thereto about an instantaneous sway axis through a point 950 located at the intersection of lines through the points 946 and 947. Wheel mouning location members in the form of location arms 951 pivotted on the support member 931 about axes through points 952 permit the wheels 934 to move upwards and downwards about the roll centre 944 in conjunction with the control arms 948 which form horizontal parallelograms with the location arms 951. The wheels 934 are resiliently mounted by virtue of spring shock absorbers 953 which are connected to the support member 931 at points 954 and to the mounting 935 through points 955 on the location arms 951. The control links 945 together with the control arms 948 form the control link means whereby lateral movement of the centre of gravity 933 relative to the support member 931 during cornering, in combination with the effect of weight transfer on the resilient part of the suspension, results in an opposite lateral movement of the tops of the wheels 934 relative to the support member, the final attitude being either that of a vertical body and wheels or a banking body and wheels, depending upon the geometric factors and stiffness of the resilient mounting selected.

In fig. 22, parts corresponding with those described with reference to figs. 1 to 3 are given the reference numerals used in figs. 1 to 3 with the addition of the suffix letter X. The body 30X is mounted on the support member 31X by means of two control links 45X which are pivotally connected intermediate their ends to the support member 31X about laterally spaced link axes through points 46X, the upper ends of the links 45X being pivotally connected to the body 30X about axes through points 47X so that the instantaneous chassis sway axis is located at a point 48X determined by the intersection of lines through the points 46X and 47X. The wheel mountings 35X are in two parts, a hub carrier 49X which is steerable about an axis 50X relative to a spring mounting portion 51X. Wheel mounting location members in the form of pairs of location arms 52X are provided, the arms 52X of each pair flanking one of the mountings 51X and having their outer ends pivotally connected thereto about longitudinal axes through the joints 36X and through the lower steering joint (not seen in fig. 22). The inner ends of the location arms 52X are guided in twin parallel tracks 53X for vertical up and down movement relative to the support member 31X. The springing for the spring mounting portion 51X is by means of conventional coil spring shock absorber units 54X the upper ends of which carry the upper suspension joints 37X which are connected to the lower ends of the control links 45X.

The action of the suspension of fig. 22 is similar to that described for fig. 5.

Figs. 16 to 21 illustrate the form of resilient wheel mounting referred to in the descriptions of figs. 1 to 6 and fig. 13, and in figs. 16 to 21 the wheels, wheel mountings and upper and lower suspension joints are given the reference numerals used for the corresponding parts in fig. 1. Each wheel 34 including its rim 45 is secured to a stub shaft 46 which is supported in bearings 47 and 48 the outer tracks of which are located in the hub portion 49 of a suspension housing 50. The wheel mounting 35 is provided with parallel roller tracks 51 which co-operate with the hub portion 49 to permit vertical up-

ward and downward movement of the suspension housing 50 relative to the wheel mounting 35. Within the suspension housing are members of yieldably resilient material in the form of twin rubber "muscles" 52 each of which has a face 53 bonded to the mounting 35 and an anchorage 54 secured to the suspension housing 50. (figs. 18, 20 and 21). Each rubber "muscle" 52 has two internal chambers 55 and 56 separated by a partition 57 having a valve 58 adapted to control the rate of flow of a fluid from the chamber 55 to the chamber 56 and *vice-versa*. Each valve 58 may be, for example a spring loaded two-way ball valve, or simply an orifice of a predetermined size. During deflection of the rubber "muscles" 52 the chambers are deformed as illustrated in figs. 20 and 21 and the controlled flow of fluid between the chambers provides a double shock-absorbing action. The chambers 55 and 56 may be filled or partially filled with a liquid, for example an oil or other liquid of specified viscosity.

Although the embodiments of the suspension systems herein described relate to the front suspension of a wheeled vehicle, the invention as defined in the appended claims is applicable to the rear suspension of a wheeled vehicle and may be applied to both front and rear in the same vehicle. In the embodiments described, it is preferable that the body is torsionally stiff.

WHAT I CLAIM IS:—

1. A wheeled vehicle including a body, a support member arranged transversely of the vehicle generally in the vertical plane containing the axis of rotation of a pair of wheels of the vehicle, the body being mounted on the support member at a point or at points thereon above the centre of gravity of the body for lateral swaying movement relative to the support member about a sway axis above the centre of gravity of the body, wheel mountings one for each wheel of the said pair, each mounting having a lower suspension joint and an upper suspension joint, wheel mounting location members each connecting one of the lower suspension joints to the said support member and providing transverse location of the wheel mountings, control link means connecting the upper suspension joints with the body whereby movement of the body in one lateral direction relative to the support member causes movement of the upper suspension joints relative to the support member in the opposite lateral direction, and means providing longitudinal location of the wheels relative to the body.

2. A wheeled vehicle according to claim 1, wherein the wheels of the said pair are resiliently mounted for independent upward and downward movement relative to the said support member about a point located below the centre of gravity of the body.

3. A wheeled vehicle according to claim 2, wherein said point is located at road level.

4. A wheeled vehicle according to claim 3, wherein the hubs of the wheels of the said pair are resiliently mounted for independent vertical movement relative to their associated mountings, the said wheel mounting location members being fixed against angular movement relative to the support member in the vertical plane.

5. A wheeled vehicle according to claim 4, wherein the body is pivotally mounted on the support member at a point thereon coincident with a longitudinal centre line of the vehicle and the said control link means comprises control arms commonly pivotally connected to a point on the body above the said sway axis and arranged one parallel to a line passing through the sway axis and one of the lower suspension joints and the other parallel to a line passing through the sway axis and the other lower suspension joint.

6. A wheeled vehicle according to claim 4, wherein the body is pivotally mounted on the support member at a point thereon coincident with a longitudinal centre line of the vehicle, and the said control link means comprises a control link pivotally mounted intermediate its ends on the support member on a link axis extending longitudinally of the vehicle below the sway axis and above the centre of gravity of the body, and control arms commonly pivotally connected to a point on the control link spaced upwardly from the said link axis and connected one to one of the upper suspension joints and the other to the other upper suspension joint, a point on the control link and spaced downwardly from the said link axis being in transverse locating engagement with the body.

7. A wheeled vehicle according to claim 4, wherein the said control link means comprises control links pivotally mounted intermediate their ends on the support member on respective laterally spaced link axes extending longitudinally of the vehicle below the sway axis and above the centre of gravity of the body, each of said control links having one end thereof in pivotal connection with the body and the other end thereof in pivotal connection with a respective one of the upper suspension joints.

8. A wheeled vehicle according to claim 2 or 3, wherein the wheel mounting location members are pivotally connected to the support member for angular movement relative thereto in the vertical plane, and the wheels together with their respective wheel mountings are resiliently mounted for said independent upward and downward movement through resilient means connected to and extending between the support member and the wheel mounting location members, and said control

link means comprises control arms arranged in parallel with the said location members on respective sides of the vehicle.

9. A wheeled vehicle according to claim 8, wherein the body is pivotally mounted on the support member at a point thereon coincident with a longitudinal centre line of the vehicle, and the said control link means further comprises a control link pivotally mounted intermediate its ends on the support member on a link axis extending longitudinally of the vehicle below the sway axis and above the centre of gravity of the body, and said control arms are commonly pivotally connected to a point on the control link spaced upwardly from the said link axis, a point on the control link and spaced downwardly from the said link axis being in transverse locating engagement with the body.

10. A wheeled vehicle according to claim 8, wherein the said control link means further comprises control links pivotally mounted intermediate their ends on the support member on respective laterally spaced link axes extending longitudinally of the vehicle below the sway axis and above the centre of gravity of the body, each of said control links having one end thereof in pivotal connection with the body and the other end thereof in pivotal connection with respective ones of the said control arms.

11. A wheeled vehicle according to claim 4, wherein each hub is resiliently mounted by means of a member of yieldably resilient material having mutually spaced portions thereof secured to the hub and to the mounting respectively, said resilient member having internal chambers separated by a partition, fluid in the chambers, and valve means on the partition and adapted to pass fluid at a controlled rate in either direction between the chambers upon deformation of the resilient member during movement of the hub relative to the mounting.

12. A wheeled vehicle according to any one of claims 1 to 11, wherein the wheels of said pair are steerable wheels, said lower and upper suspension joints being ball joints.

13. A wheeled vehicle suspension system substantially as hereinbefore described with reference to figs. 1 to 3 or fig. 4 or fig. 5 or fig. 6 or figs. 7 to 10 or fig. 11 or fig. 12 or fig. 13 or fig. 14 or fig. 15 or fig. 22 of the drawings.

14. A wheeled vehicle substantially as hereinbefore described with reference to figs. 1 to 3 or fig. 4 or fig. 5 or fig. 6 or figs. 7 to 10 or fig. 11 or fig. 12 or fig. 13 or fig. 14 or fig. 15 or fig. 22 of the drawings.

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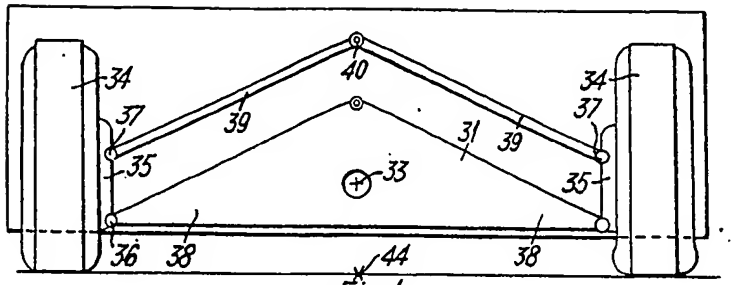


Fig. 1.

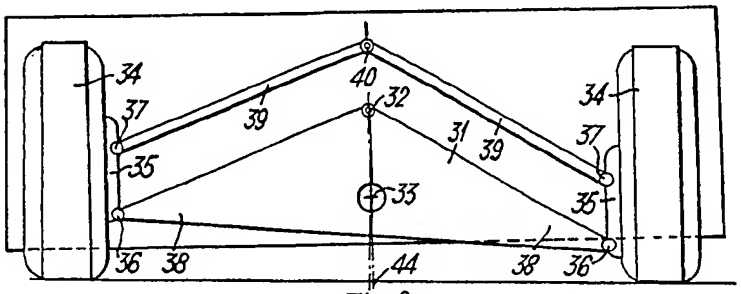


Fig. 2

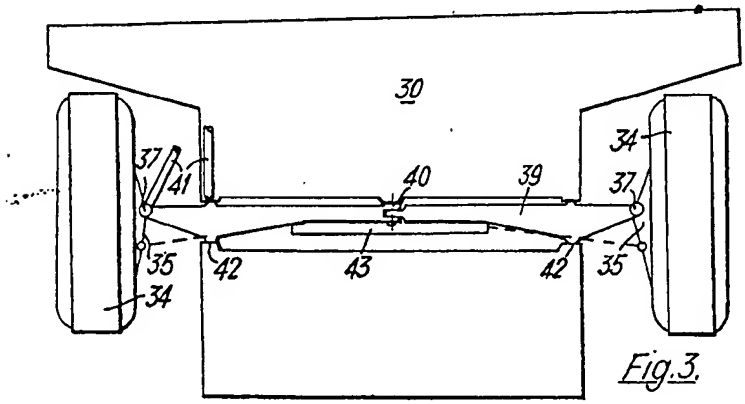


Fig. 3.

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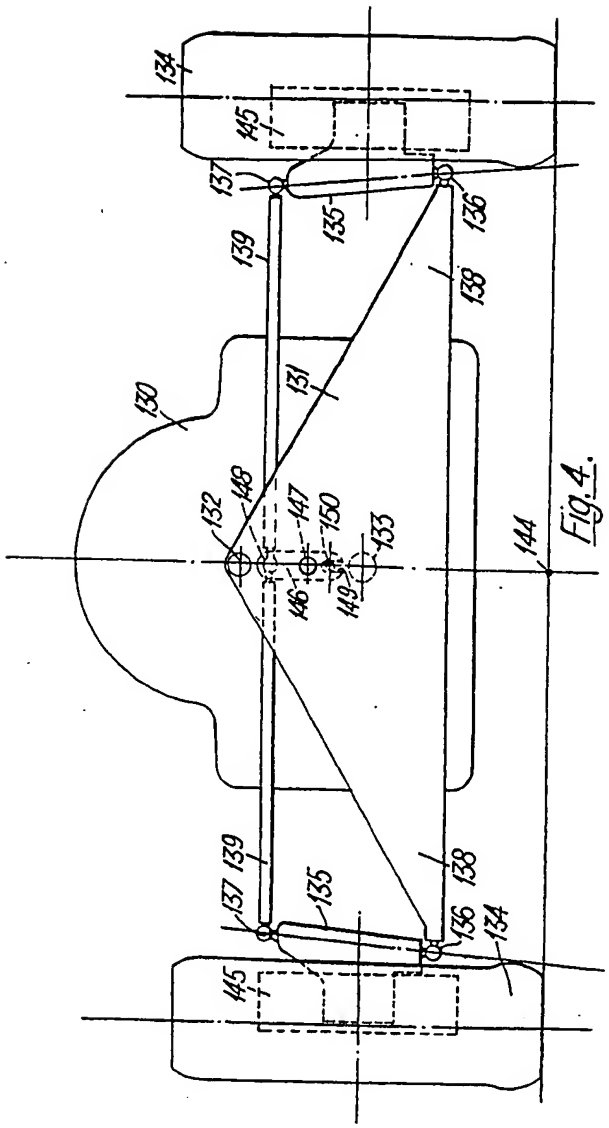


Fig. 4.

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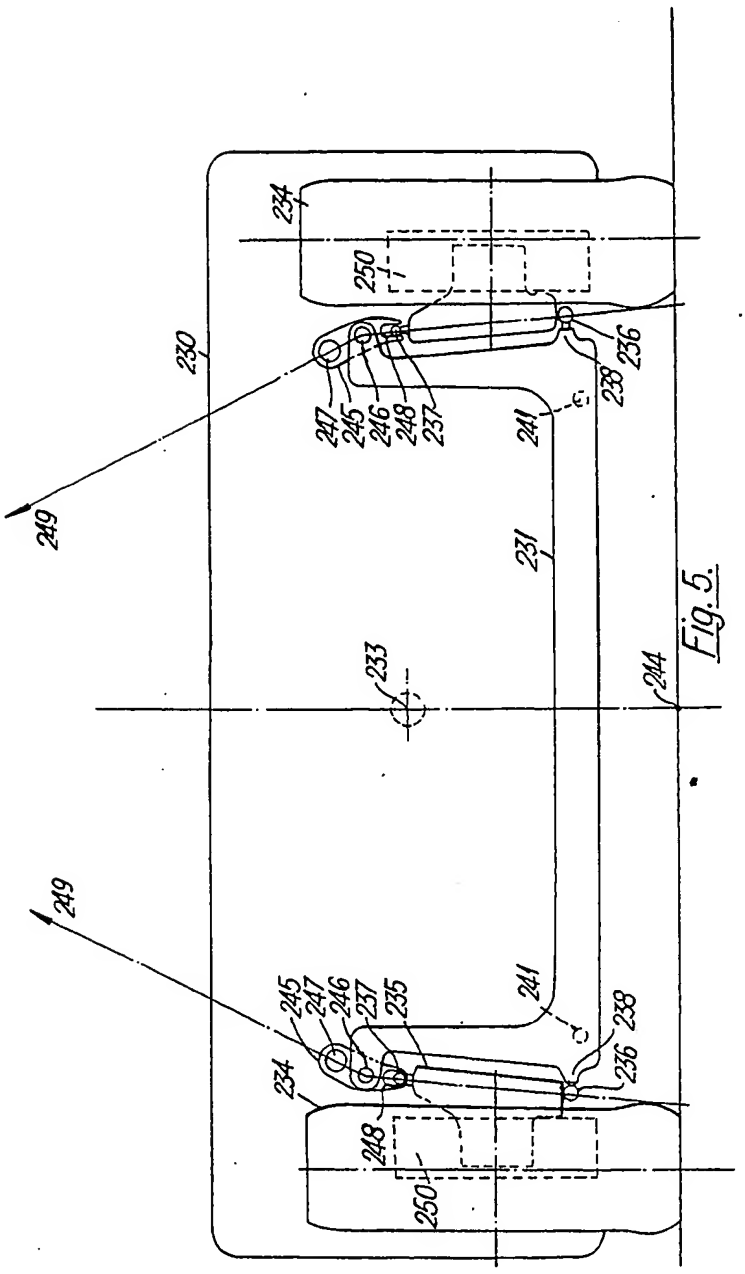


Fig. 5.

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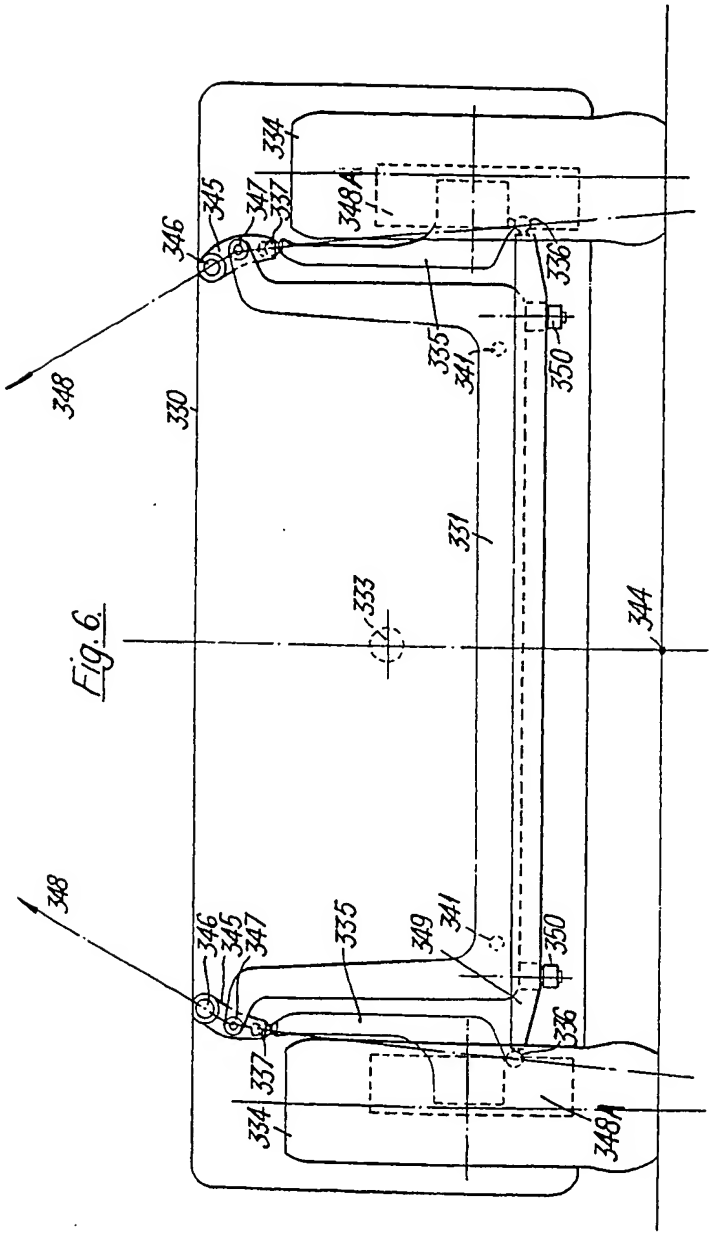


Fig. 6.

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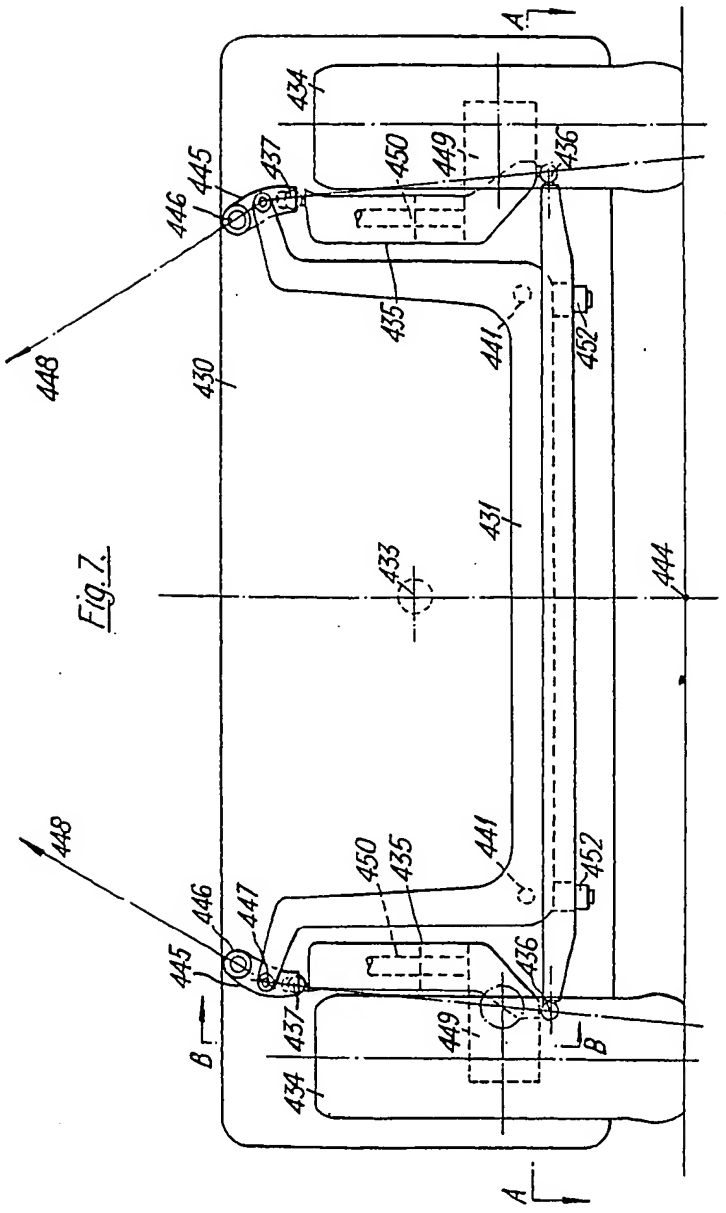


Fig. 7.

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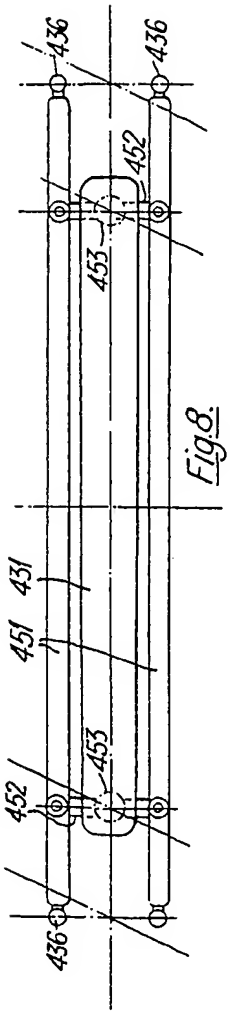
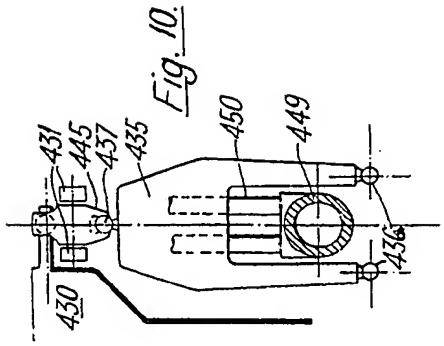



Fig.8.

Fig. 10.



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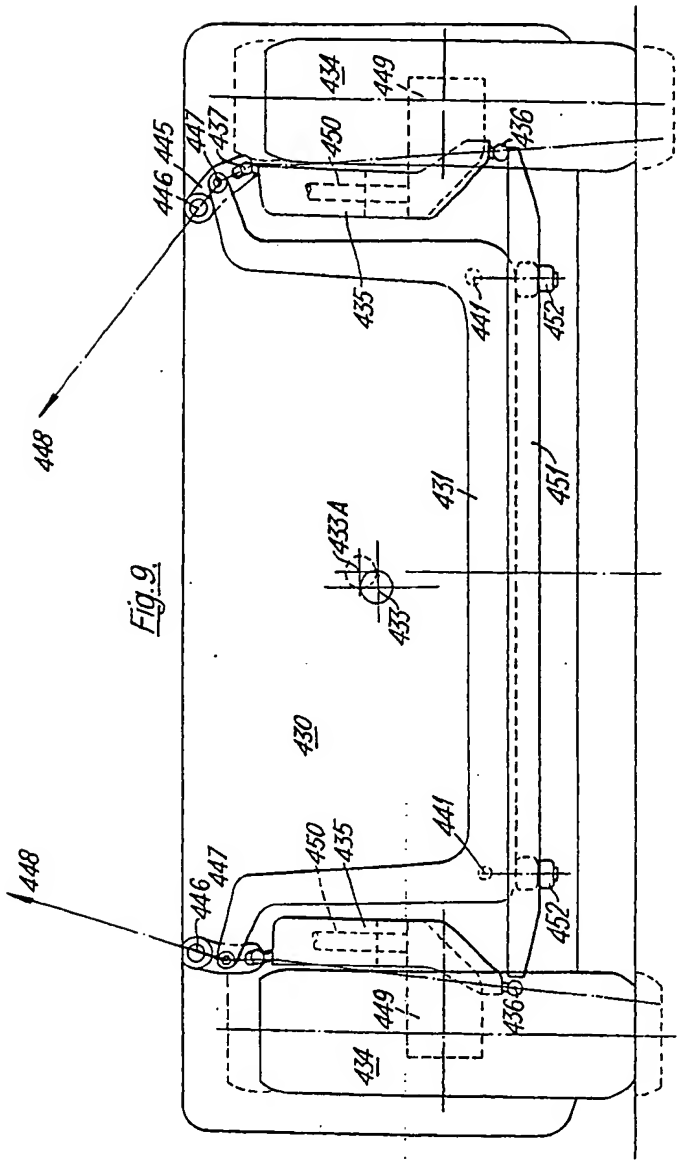


Fig. 9

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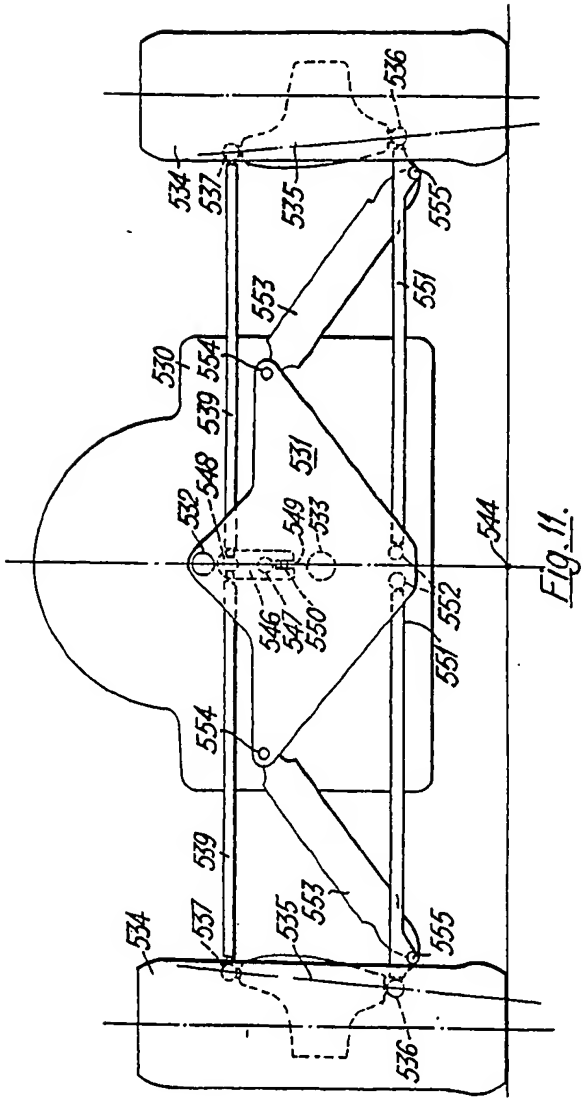


Fig. 11.

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Sheet 9

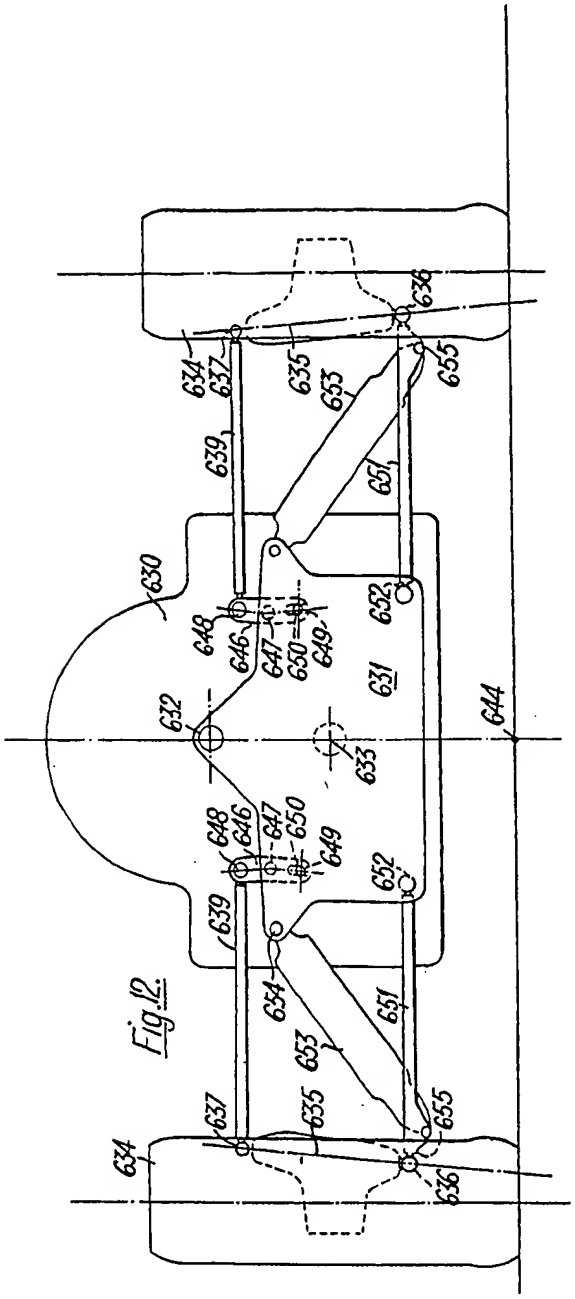



Fig.12.

1213795 COMPLETE SPECIFICATION

16 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 10

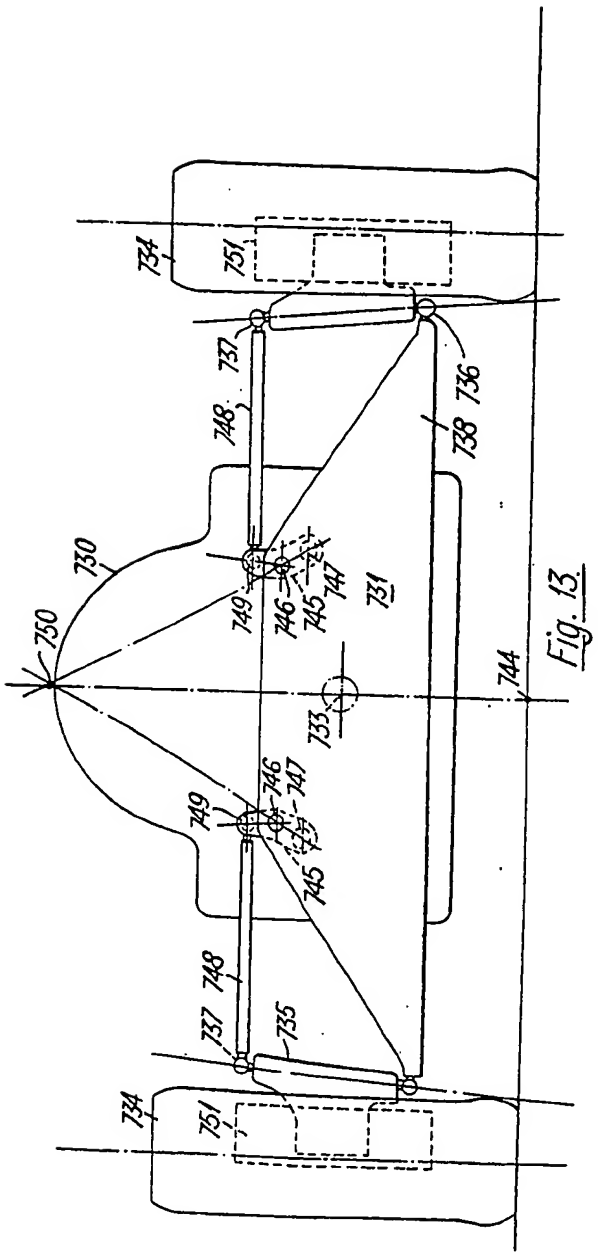



Fig. 13.

1213795 COMPLETE SPECIFICATION
16 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 11

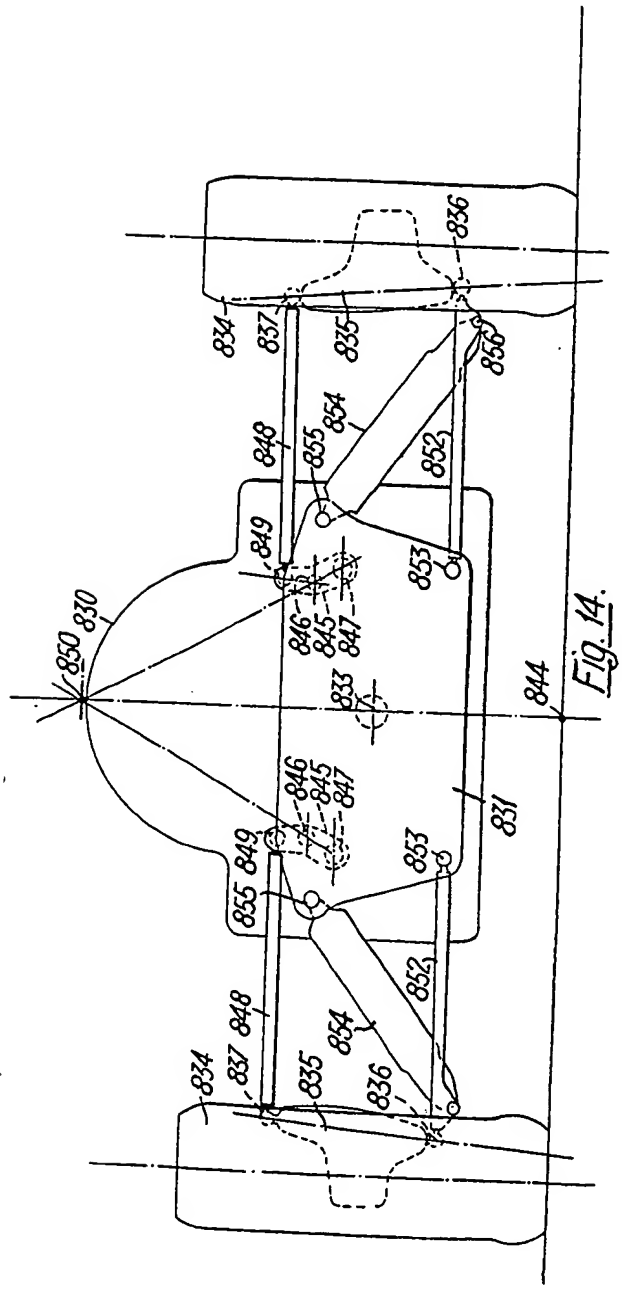



Fig. 14.

1213795 COMPLETE SPECIFICATION
16 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 12

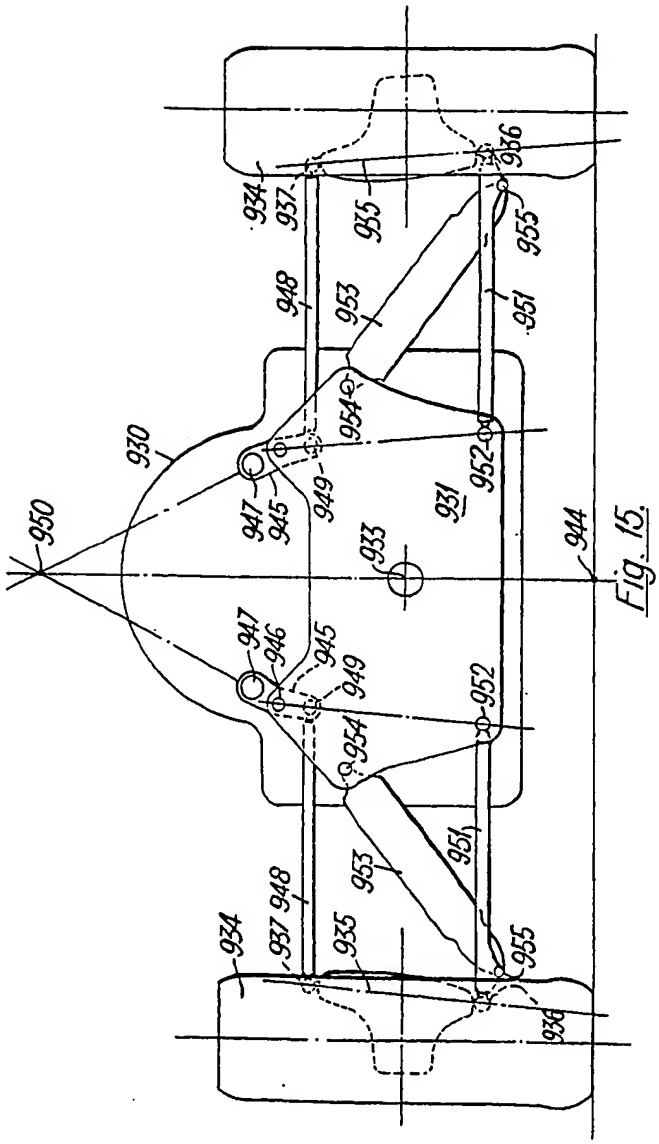



Fig. 15.

1213795 COMPLETE SPECIFICATION
16 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 13

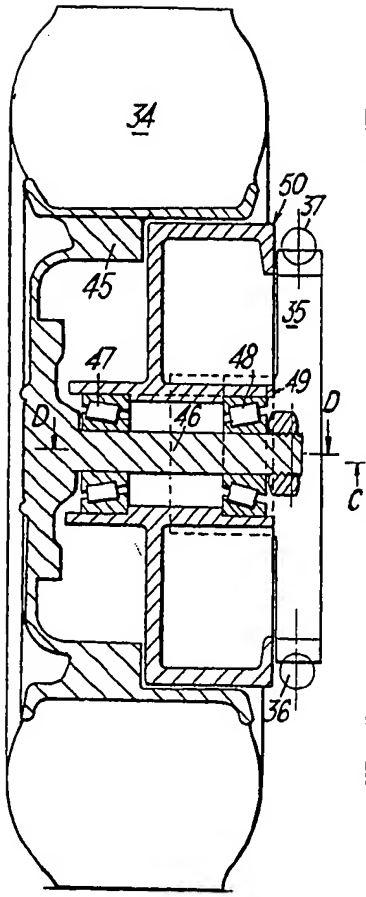



Fig. 16.

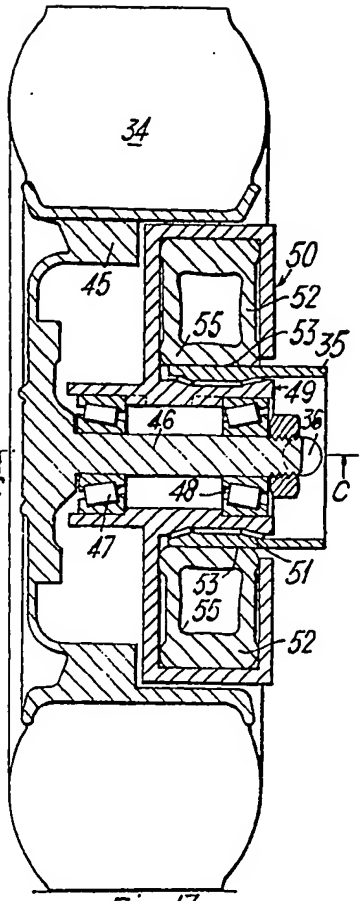
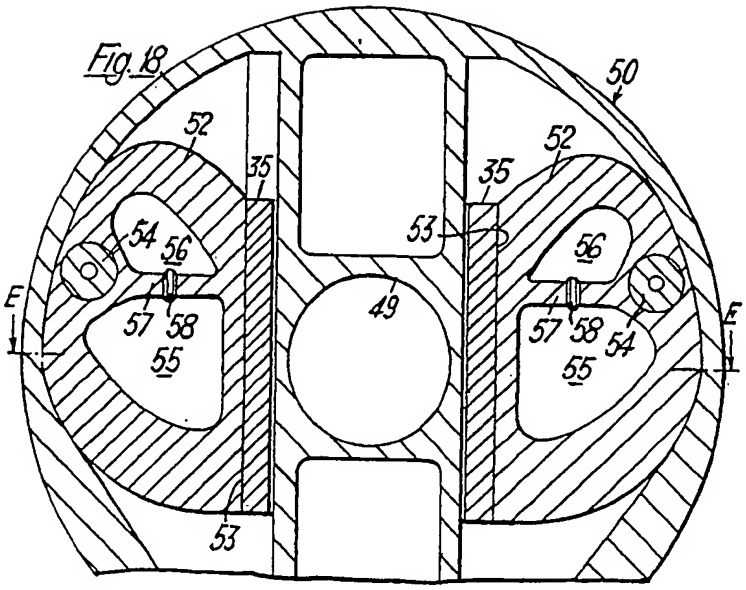



Fig. 17.

1213795 COMPLETE SPECIFICATION
16 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 14



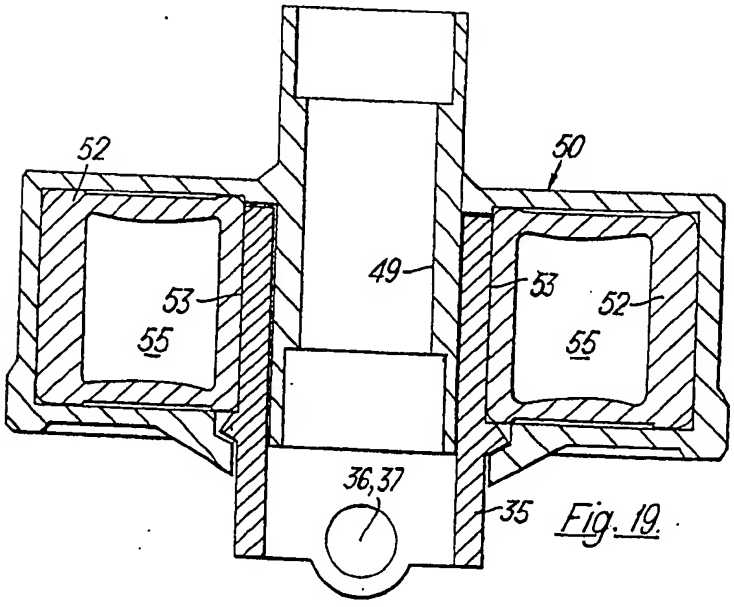




Fig. 19.

1213795 COMPLETE SPECIFICATION
16 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 15

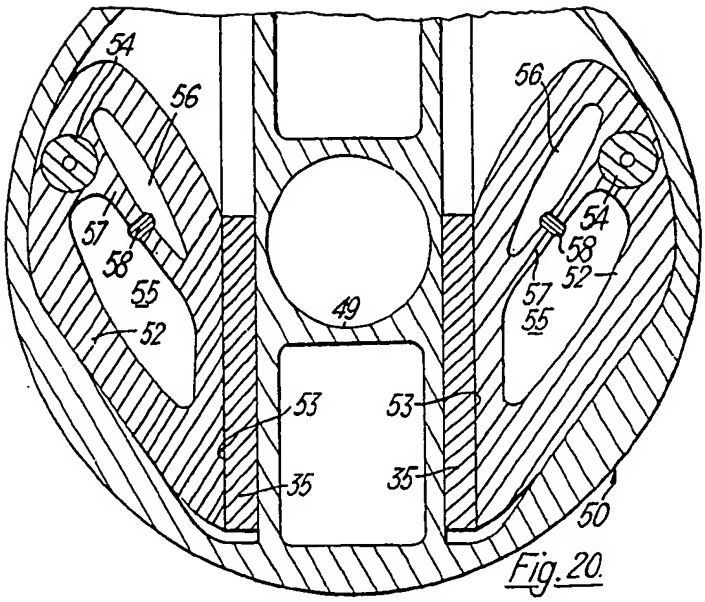
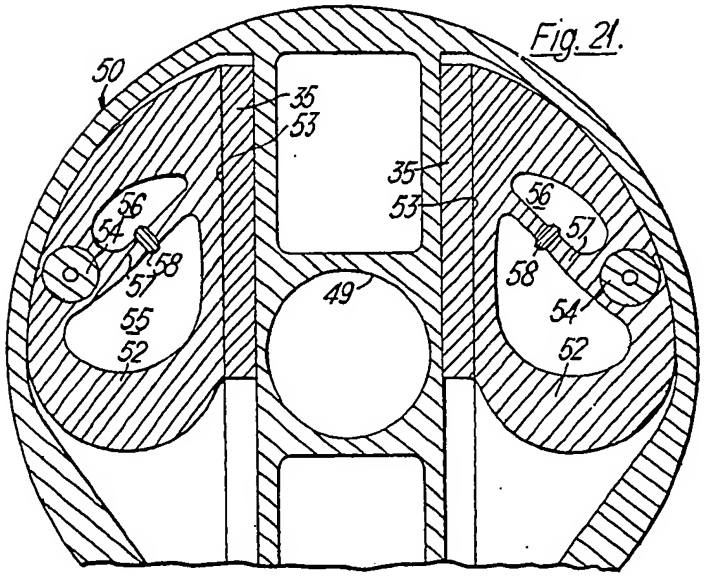



Fig. 20.

Fig. 21.



1213795 COMPLETE SPECIFICATION
16 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 16

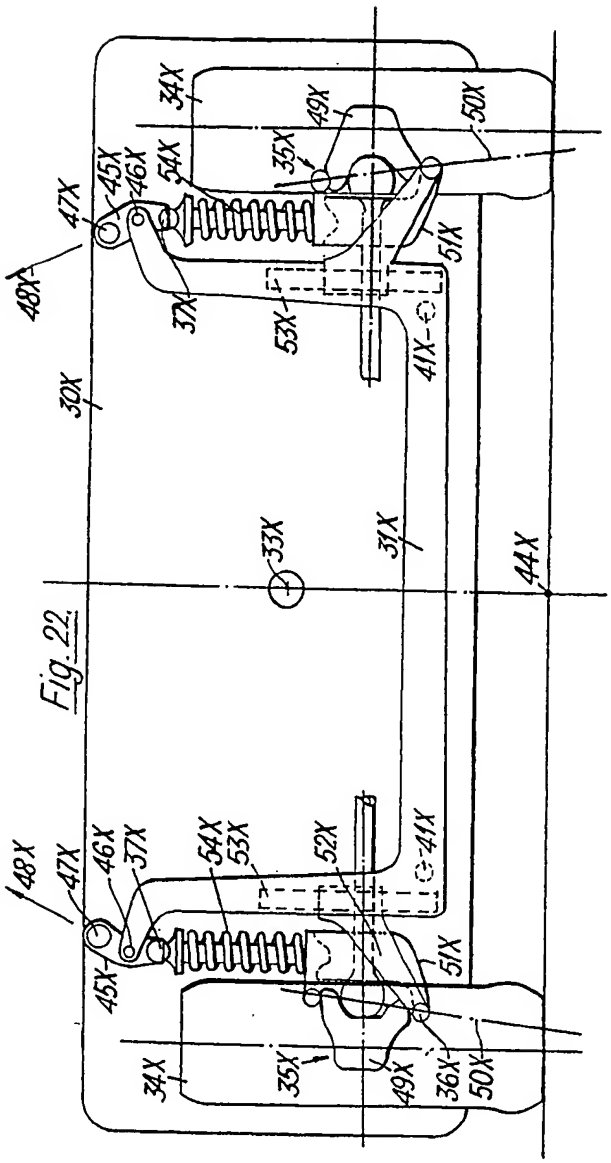



Fig. 22